SPACED RECEIVER OBSERVATIONS OF JOVIAN DECAMETER FLUX

Progress Report IV

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Under grant NGR 44-012-055 we have continued and extended the analysis of observations of decametric Jovian flux amplitude received at spaced observing sites which was begun under grant NsG-407. Under that grant a triangular arrangement of stations with baselines of 60 and 100km was set up and flux measurements at the three stations were simultaneously recorded at the base station via telephone data links. Analysis of these records, and in particular, of the second-long L-pulses present in the Jovian radiation has led to discoveries of interest pertaining to the interplanetary medium.

Early two station observations led to the discovery that the L-pulses are caused by a diffraction phenomena in the interplanetary medium. Phase variations introduced in the radiation by clouds of electrons between the earth and Jupiter lead to amplitude fluctuations in the observed flux. These fluctuations are the L-pulses.

The initiation of three station observations has enabled us to determine the velocity of the inhomogenieties in the interplanetary medium and, as shall be more fully explained, their average shape. The procedure to be followed is an extension of that used in ionospheric work.

We observe radiation for the planet Jupiter after it has traversed the medium between the source and our receivers. We observe amplitude scintillations, L-pulses, in our records at the three stations. Autocorrelations of amplitude in time for each station are calculated along with cross correlations between stations. This calculation is straight forward once the analog records have been reduced to digital form. Correlation of amplitude as a function of distance in the observing plane is related to the spacial autocorrelation of electron density in the medium. If the medium is stable for times long compared to the duration of the amplitude fluctuations then these fluctuations in time are simply related to the spacial correlation contours. The time contours are equivalent to spacial contours along the direction of motion of the medium. It can be shown that in the most general case the autocorrelation contours are similar confocal ellipses. Any section through the center of these contours, for example the time autocorrelation recorded at one station, is similar to any other section through the center. Thus, we may define a quantity with dimensions of velocity which gives the factor by which the time argument of the autocorrelation function must be multiplied to give the autocorrelation in terms of spacial argument. This quantity will, in general, be a function of direction. For simplicity we will call these quantities velocity factors. We would observe the recorded amplitude fluctuations if the inhomogeneities causing them were moving in any direction with the velocity factor appropriate to that direction. They are in fact moving along only one such direction but the concept turns out to be extremely useful.

The velocity factor can be determined from our data in the following way. We have a cross correlation of amplitude between stations. Let one station be at the origin. We can write this cross correlation as

$$\rho(\xi_i, \eta_i, t)$$

our autocorrelation in time is

$$\rho(0, 0, t)$$

for each station we can find a delay t_i such that

$$\rho(0, 0, t_i) = \rho(\xi_i, \eta_i, 0).$$

Our velocity factor in the directions

$$\vec{X}_i = \xi_i \underset{\sim}{i} + \eta_i \underset{\sim}{j}$$

is then simply

$$\vec{V}_i = \vec{X}_i / t_i.$$

It is apparent from the nature of the velocity factor that for any constant t

$$\vec{V}_i t = \vec{Y}_i$$

such that

$$\rho(\vec{Y}_i, 0) \text{ is a constant.}$$

Each $\vec{V}_i$ determines a new $\vec{Y}_i$ but the value of $\rho(\vec{Y}_i, 0)$ remains constant. This important property allows us to determine the shape of the contours of constant amplitude and the shape of these contours is, as has been explained, just the average shape of the irregularities causing the scintillation. From the three station data we determine three Y_i. The positions of the stations projected into the plane perpendicular to the line of sight to Jupiter gives us the directions and if we set t = 1 we have

$$\vec{Y}_i = \vec{V}_i$$

and we can determine $|V_i|$ directly from our data as outlined in the definition of V_i. Having determined three points on an ellipse and knowing its center we have determined the ellipse.

One event has been analyzed more or less by hand and computer programs are being prepared to put the job on a production basis. The event examined, that of 23 October 1965, led to a derivation of the shape of the correlation ellipse as an ellipse of arial ratio 4:1. This ellipse was inclined to the projection of the ecliptis by some 35°.

Previous analysis showed that on this day the motion of the irregularities was essentially along the projection of the ecliptic -- a fact consistent with radial motion from the sun. The shape of the irregularities may affect this result to some degree but should not change it drastically.

We note with interest that the contours are elliptical. This can only occur if there is a systematic effect in the interplanetary medium. Possibilities which come to mind include elongation of inhomogeneities along magnetic field lines are along velocity vectors.

Clearly we are at an extremely interesting point in our analysis. The complete analysis of some tens of events now in hand will be extremely interesting. A cause for concern and caution is the effect of ionospheric scintillation on the observed cross correlation functions. Clearly any such scintillation will systematically lower these functions. Theoretical analysis of this problem is under way. At this point in the analysis it appears that accurate shapes will indeed be available as outlined above. However accurate determination of the size of the inhomogeneities may require measurement of ionospheric scintillation over baselines long compared with the correlation distance for such scintillations (kilometers) but short compared with the interplanetary correlation distances (hundreds of kilometers). A study of Jovian flux at stations separated some 10km may prove to be the most useful way to obtain this information.

Work proceeds on the manual digitization of analog records, on the analysis of such records, and on the theoretical aspects of the scintillation problem.